8. Dissemination

8.1 Introduction

This chapter describes the results of the project dissemination activities undertaken in Dhaka, Bangladesh and in Grand Turk, Turks and Caicos Islands by Dr Ashley Halls and Mr Crag Jones. The main vehicles for dissemination at both sites were workshops, presentations and demonstrations of the FIMS software aimed at target beneficiaries, other stakeholders, and the project's collaborators. For the reasons stated in Section 1.5.2 no training was given in sampling methodologies to provide the array of potential raw data that can be accepted and processed by the FIMS.

8.2 Dhaka, Bangladesh (4th - 8th December 2000)

Dissemination activities in Bangladesh comprised (i) a one-day general workshop attended by NGOs, the academic community and international donor and development agencies, followed by (ii) a half-day software demonstration workshop held at CARE Headquarters, and (iii) a presentation of the projects findings and demonstration of the software to the DoF at their Headquarters.

8.2.1 One Day Workshop: ' A Database and Analytical Framework to Support the Co-Management of Artisanal Fisheries in Bangladesh'

The workshop was held at the Dhaka Ahsania Mission, Dhaka on December 6th. In spite of requested efforts by DFID to encourage participation, attendance by DOF staff was poor and therefore a second presentation and software demonstration was organised at DOF the following day (see below). Twenty-five of the 54 invited participants attended (✓):

Department of Fisheries, Bangladesh

Dr M.A. Matin, Director General, Fisheries Management and Administration
Dr Mokammel Hossain, Director CBFM
Dr Nassirudin Ahmed (FRSS)
Dr Anwar Hossain (FRSS)
Dr Rhakal Chandra Banik (FRSS)
Dr Nassirudin Ahmed, Project Director, Fourth Fisheries, DOF
Mr Monir Hossain, Deputy Assisstant Director, Fourth Fisheries Project, DOF ✓

International Donor Agencies

Mr Donal Brown, Natural Resource Advisor, DFID
Mr Tim Robertson, Fisheries & Aquatic Resource Advisor, DFID
Mr Duncan King, Fisheries Field Manager, DFID
Mr Imtiazuddin Ahmed, The World Bank
Dr Mahfazul Ahmed, UNDP, UN
Dr Aminul Islam, Sustainable Development Advisor, UNDP, UN
Mr Goutam Chandra Dhar, GIS/Database Programmer, FMS, DFID ✓

Research / Development Agencies

Dr Tony Thompson, SUFER Project, DFID ✓
Dr Paul Thompson, Officer in Charge, ICLARM ✓
Mr Md. Nural Islam, Social Scientist, ICLARM ✓
Mr Md Manjur Kadir, Fisheries Biologist, ICLARM
Mr Debashish Mazumder, Fisheries Biologist, ICLARM
Mr William Collis, Winrock International, MACH, USAID
Mr Darrell Deppert, Winrock International, MACH, USAID ✓

Mr Khaja Ahmed, Program Officer, DANIDA	
Mr Robert Koudstaal, Team Leader, EGIS	
Ms Ingrid Gevers, Fisheries Expert, EGIS	✓
Mr Md. Giaruddin Khan, EGIS	✓
Mr Md Abdullah-Al-Mamun, Fisheries Biologist, EGIS	✓
Mr Md. Gias Uddin Khan, Fisheries Specialist, EGIS	✓
Dr Ainun Nishat, Country Representative, IUCN	✓
Mr Rashiduzzaman Ahmed, SEMP Project, IUCN	✓
Gertjan de Graaf, Fisheries Consultant	
Fourth Fisheries Project	
Mr David Edwards, Team Leader	
Mr Iqbal Hossain, Assisstant Director, M&E	✓
Mr Mohammad Ali, Deputy Assistant Director, M&E	
Mr Willie Bourne, M&E Specialist	✓
Mr Zahirul Islam	
Mr Mokhlesur Rahman, M&E Specialist	
NGOs	
Mr Md. Mokarom Hossain, Sector Specialist, BRAC	
Mr Shankar Kr. Biswas, Sector Specialist, BRAC	✓
Mr Abdur Rahman, Fisheries Coordinator, PROSHIKA	
Mr Shahadat Swapon, Associate Coordinator, PROSHIKA	✓
Ms Anwara Begum Shelly, Director Fisheries, CARITAS	
Mr Phanindra Sangra, Prgram Officer, CARITAS	✓
Mr Lizarez Rahman, CARITAS	✓
Mr Sachindra Halder, Director, CNRS	✓
Mr Mokhlesur Rahman, Executive Director, CNRS	✓
Mr Kamal Uddin, Fisheries Biologist, CNRS	✓
Mr M. Anisul Islam, Program Officer, CNRS	✓
Mr Md. Hannah, CNRS	✓
Mr Greg Chapman, Rice-Fish Program Coordinator, CARE	
Mr Mike DeVries, ANR Sector Coordinator, CARE	
Mr Faheem Khan, MIS Advisor, CARE	
Mr Shouroni Zinnat, Assisstant Project Coordinator, CARE	✓
Dr Atiq Rahman, Director, BCAS	
Mr Syed Shah Tariquzzaman, SAREAA	✓

The workshop was divided into three sections (i) assembly, and introductions (ii) presentations by Dr Ashley Halls and Mr Crag Jones, and (iii) a discussion session. Finally, Moklesur Rahman (CNRS) summarised the findings of the project and formally closed the workshop.

The presentation given by Dr Ashley Halls described the project purpose, and the theoretical approach and activities employed to identify generic information and data inputs and outputs upon which the datamodel and software were developed. Mr Crag Jones then described the development of the datamodel and the functions of the database highlighting how some of the basic principles of relational database structuring and querying could profitably be applied as a generic system to cover the wide range of fishing situations in Bangladesh.

During the discussion session, participants were encouraged to comment on the results of the work. Suggestions and recommendations to improve the FIMS, particularly with respect to it's utility and applicability to the fisheries of Bangladesh but also to artisanal fisheries more generally, were also sought.

Overall, the project results were well received by all participants who expressed an opinion. Many participants supported the concept of learning lessons about (co-)management on the basis of spatial comparisons of standard, commonly-agreed management performance measures/indicators and those explanatory factors (co-management attributes) that are likely to affect performance (see SIPA - Section 6.6). This approach was regarded as particularly pertinent when funding constraints limit long term monitoring and evaluation and where the effects of influential environmental factors (eg flooding intensity and duration) need to be distinguished ('factored-out') from the effects of management intervention.

Participants agreed amongst themselves that floodplain elevation, flood duration, and flood depth are important attributes that should be included in the FIMS. It was also recommended that Catch Per Unit Area (CPUA) should be included as a co-management performance indicator.

Several participants expressed the opinion that DoF lacked the necessary institutional capacity and resources to replace the existing FRSS system with the PISCES software. Capacity building and training were seen as vital before the system could be implemented effectively by the Department due to the complexity of the system. However, some felt that the additional monitoring activities of co-managed units/projects required to support the SIPA elements of the system may be achievable if District and Thanna Fisheries Officers were supplied with networked computers to allow remote data entry from a local spatial scale. Alternatively, NGOs and donor project staff could undertake this role themselves if mutually agreed standard measures and indicators were employed for every study/project. These may have to include a common sub-set of donor-approved project impact indicators and measures to satisfy their own basic contractual reporting requirements. The latter solution raised questions surrounding ownership rights over the data and who would facilitate and coordinate the monitoring, evaluation and lesson feedback activities.

Many participants representing NGOs recognised that whilst the FIMS is primarily aimed at fisheries departments, the system could be used as a monitoring and evaluation tool to store and process data on local or small scale projects and studies.

Several institutes/projects expressed an interest to collaborate with MRAG, either with respect to helping DoF adopt the PISCES or to help develop the SIPA approach as part of the on-going DFID funded project 'Interdisciplinary Multivariate Analysis (IMA) for Adaptive Co-Management' (R7834).

Representatives of the EGIS project, who have forged a strong working relationship with the DoF during the last two years, believed that the FIMS would be a valuable tool for the Department, and that the system's implementation should be encouraged. EGIS expressed an interest to collaborate with MRAG if an implementation project were funded.

Dr Paul Thompson from ICLARM, Director of the Community-Based Fisheries Management (CBFM) Project in Bangladesh expressed interest in collaborating with MAG. on the IMA project. He suggested that Phase II of the CBFM project could be used to test or validate the IMA statistical methodology if the measures and indicators agreed under the IMA project were employed from the start of the next monitoring and evaluation phase of the CBFM.

Delegates from the Fourth Fisheries Project also expressed interest in collaborating with the IMA project in support of their Fish Sanctuary Programme. They agreed to give further consideration to some form of collaboration after receiving and assessing the Final Technical Report and FIMS software.

Darell Deppert (MACH Project), also believed that the SIPA approach could have an application in the MACH Project and supported the use of a common/standard det of co-management

performance and attribute measures and indicators.

Tony Thompson (SUFER Project) suggested that MRAG give the same workshop presentations to Bangladesh Agricultural University and other interested university departments as a means of encouraging the co-management paradigm as well as teaching staff and students about approaches to monitoring and evaluation.

Most of the partcipants present requested to receive copies of the Final Technical Report and FIMS software (see Section 9.4) so that they could explore the utility and applicability of the system for themselves in more detail. All participants were invited to attend a demonstration of the FIMS software at CARE HQ the following day (see below).

8.2.2 Software Demonstration at CARE

A workshop to demonstrate the FIMS software was held at CARE Headquarters on the morning of the 7th December. The following NGO representatives attended:

Mr Sachindra Halder, Director, CNRS
Mr Shaheen Ferdurs, CARE Bangladesh
Mr Selim Reza Hasan, CARE Bangladesh
Mr Uzzal Kumar Roy, CNRS
Mr Mir Atuar Rahman, CARE Bangladesh
Mr Mohammed Sylas, CNRS
Ms Asthma Alam, CARE-CAGES
Mr Alamgir Rahman, CRAE-CAGES

The presentation and demonstration was given by Mr Crag Jones who began with a resume of the project purpose and activities and some technical theory relating to data structures and datamodels for the benefit of those who did not attend the workshop on the previous day. He then gave a comprehensive demonstration of the software.

The theoretical aspects were illustrated with both simulated data and historical data collected for the river fisheries of Bangladesh. The concept of both capturing and representing complexity via the data content as opposed to via data structures was illustrated. The design and utility of a single generic structure to contain such data was demonstrated.

It was shown how this structure (table) has all the relevant attributes (fields) that describe fishing events. Such attributes would be both the inputs and outputs in terms of physical data and measures that profile management areas and measure the performance of management areas.

It was then shown that a range of performance attributes could be analysed against any of the physical or management attributes or any number of combinations of these according to the users choices. This was shown to allow a choice of analyses from the traditional physical kinds all the way through to a comparison between different co-management arrangements.

The choice of whether any one attribute is regarded as an ‘input’ or ‘output’ was explained as an arbitrary one based on the investigators assumption of cause and effect for each of the analytical queries provided. It was shown that the distinction could thus be ignored, thereby meaning that data structures do not have to confine the range of possible analyses allowing more to be added as required.

The example was made where the species attribute could be used as a ‘generic input’ for catch analysis but as a performance indicator where used in the analysis of bio-diversity. The analogous view point was shown to be applicable such things as exploitation methods and exploitation intensity.

Attention was drawn to the fact that additional analyses can be developed confident in the knowledge of a standard source of input data which would ease the comparison between different lines of investigation. That this would also ease the task of preparing datasets in the required format for external analytical tools such as statistical packages was also stressed.

In practical terms it was shown that you could analyse for effort, catch, costs, earnings, income, frame survey effort and the application of this to all the sample data to obtain 'raised' results as nation wide estimates of these. There were also examples given of the mapping of fishing income into communities, the use of household survey data to give estimates of levels of distribution and degree of equity, analysis of species diversity within the fishery, degrees of conflict and detailed biological sampling measurements and analysis of these.

It was demonstrated how all of the outputs from these example analyses could be plotted via a single generic plotting routine that automatically scaled and labeled the axes and data series according to any time series if so chosen. The automatic availability of the results for export to spreadsheets was shown.

It was explained that the user could analyse say a count of species or diversity index plotted against the years for all combinations of Intermediate Management Area in conjunction with the degrees of enforcement of regulations, or compare diversity under specific management plans combined with degrees of fisher representation in the management process. However the lack of either real or simulated example data with these properties precluded a clear demonstration of this which was reserved for the following demonstrations at DoF once example data had been simulated. A more conventional example was given using the real data to give be raised catch estimates by species per gear type per habitat per month etc. Results sets can be grouped according to the values under any number of the fisheries attributes or combinations of these.

It was shown how the FIMS could cope with unanticipated attributes in real Bangladesh data such as the need to express 'District Code' in conjunction with particular Rivers. It was demonstrated that all of the attributes of the original data were preserved after the transformation into the FIMS but that the flexibility by which it could be analysed and illustrated was greatly enhanced. Examples were run of the river data being broken down by species, gear type, village, district, river with or without a time axes of year alone, month alone or combination of year and month.

It was emphasised that the time series attributes are structured and handled in the same fashion as all others except at the plotting stage where they are projected onto their own axis in order to aid visualization. The unique combination of all the values under the attributes that the user chooses to group their results by (the 'strata') are automatically formed were shown to plot as separate series either in the third dimension or as separate lines on a two-dimensional plot where this was clearer.

The unique method of grouping and matching both the frame effort and the sample effort and catch according to matching criteria chosen by the user was clearly demonstrated with real frame data from Bangladesh providing results that closely matched the DoF published results from this data.

It was shown how the system could cope with both detailed data and higher level summary data depending on the survey methods and sources and that such diverse data could also be combined in analyses whilst maintaining an accurate representation of effort at each level.

Attention was drawn to the need for responsibility on the part of the user in return for the flexibility offered by the system. It was pointed out that the data entered should be in a form appropriate to the type of analysis that was envisaged and that the portioning of effort across categories

should be appropriate to the level of detail in the data. The existing facilities within the software to handle catch per unit area and raise this according to flood plain area were also discussed.

It was shown how the original FRSS data set had been radically transformed whilst at the same time markedly improving its referential integrity and that similar transformation procedures could be applied to data from the other fisheries. At present for example Bangladesh river data sits happily beside Carribean reef fishery data inside the FIMS with no loss in the range of analyses that can be applied.

Tony Thompson had earlier pointed out the lack of understanding and awareness amongst researches and managers, the world over, of the potential of relational database methodologies for fisheries management; and the need for additional training in this area. This was met with general agreement.

Dr Paul Thompson, highlighted the need for indications of sample sizes and variability of data. It was reported that, time allowing, it was relatively straightforward to place these important aggregate functions within the existing grouping architecture that the analyses suite was based on.

Detailed discussions were held with the software specialists at CARE concerning the structure of the data model and the various modifications that had to be made to allow for missing data where these were irrelevant for a particular implementation. The method of dynamically forming the SQL queries according to user choices was also described.

8.2.3 Presentation and Demonstration at DoF Headquarters.

A second presentation of the project activities and results, and demonstration of the FIMS software were given to the DoF staff at their headquarters on the afternoon of the 7th December. Participants included:

Dr Mokammel Hossain, Deputy Director
Dr Nassirudin Ahmed (FRSS)
Dr S.N. Choudhury, Principal Scientific Officer
Mr Md. Zahirul Islam, Fisheries Management Specialist, Fourth Fisheries Project
Four IT specialists from the FRSS Department

Dr Ashley Halls began with a short presentation describing the background to the project, it's purpose and the research activities undertaken. Mr Crag Jones then gave a demonstration of the FIMS software.

Emphasis was placed upon demonstrating the practical aspects of the software using the DoF river fishery data set to illustrate the enhanced data integrity and flexibility of analysis available with the FIMS. Examples of how information can be displayed graphically or exported to spreadsheet for further analysis, were also presented.

Simulated data sets were used to demonstrate the features of direct relevance to co-management. It was shown how users could examine the correspondence between selected attributes (types of operational rules, fishing gears employed, presence/absence of reserves...etc) and management outcomes such as annual yield or local biodiversity. It was pointed out that the set of attributes and management performance indicators could be further changed or expanded. The same demonstrations of the software functions given at CARE were repeated.

The storage and analyses of biological data were illustrated including the plotting of length

frequency distributions. Methods of transforming the original data from its FRSS format into that required by the FIMS was discussed. It was explained that the data structures had been designed to take all of the other fisheries of Bangladesh into account and that similar data transformation exercises could be carried out on that data such that data from all of the fisheries could sit side by side in a single generic system. Attention was drawn to the realistic possibility of combined analysis without preventing the expression of attributes peculiar to one or other of the fisheries. The FIMS was presented as a potentially very useful tool to rationalise DoF data handling requirements and resolve many of the problems they are currently faced with.

Overall, the response from the DoF was very positive and they expressed interest to receive copies of the Final Technical Report and FIMS software. The department also expressed interest in being trained in the use of the software, and thought that the 'best bits' of the software should be included in the database that the Fourth Fisheries Project is currently developing to replace the existing FRSS. The workshop revealed the need to rationalise the approaches being taken by (i) this study, (ii) the Fourth Fisheries Project review of the FRSS and (iii) the work of EGIS into a coherent strategy.

8.3 Turks and Caicos Islands (11th-19th December 2000)

Dissemination activities in the Turks and Caicos comprised a combination of several meetings, two half-day workshops and a one-day software demonstration workshop held at the DECR Headquarters on Grand Turk and attended by staff from the DECR and other Government departments.

8.3.1 Meetings

The following pre-workshop meetings were held with DECR:

Tuesday 12th and Wednesday 13th December

Additional user requirements identified subsequent to the last assessment exercise in June 1999 (see Field Study 2 - Turks and Caicos Islands, Volume II) were discussed with the DECR and David Clements from the Government Statistics Department including: export records, data collected from purchasing slips and recreational diver sitings of species by location.

Friday 15th

An action plan to implement the FIMS in the DECR was discussed including the timetabling of activities, personnel requirements, funding sources and on-going technical support.

8.3.2 Half Day Workshops

Two half day workshops, following the same format as those undertaken in Dhaka, Bangladesh (see above), were held on Thursday 14th December. The following participated:

Morning Presentation

Mr Mark Day, Director
Ms Michelle Fulford, Senior Scientific Officer
Mr Wesley Clerveaux, Scientific Officer
Amber Thomas, Fisheries Officer, Providenciales

Afternoon Presentation

George Kwarteng, Consultant Programmer, Government of the Turks & Caicios Islands
Dexter Henry, TCI Computing Department
Michelle Taylor, National Parks Department
Brian Riggs, TCI Museum

For a number of reasons, the DECR decided not to invite stakeholders representing the School for Field Studies (SFS), the processing industry, the Fisheries Advisory Committee (FAC) or the fishers themselves.

The project results and outputs were well received by the participants, particularly the automatic system functions to alert breaches to technical and licensing regulations. The DECR were also impressed by the flexibility of the FIMS with respect to meeting their reporting requirements and provision of data and information for stock assessment purposes. Some participants were sceptical about the appropriateness of co-management in the TCIs because they believe that communities have no interest in conservation and that resource boundary delineation would be problematic. Conditions to support co-management arrangements were believed only to exist in and around Salt Quay, a small, isolated island with few inhabitants and fishers (see Field Study 2 - Turks and Caicos Islands, Volume II).

Others, on the other hand, were enthusiastic about the prospects for co-management and felt that the Department should consult the community more with a view to establishing co-management arrangements.

Mark Day, Director, DECR expressed considerable interest in installing the FIMS software in the Department to replace the existing, but no longer functioning, DataEase system (see Field Study 2 - Turks and Caicos Islands, Volume II). He intends to seek DFID development funds for a package to install and customise the FIMS, and to institutionally strengthen and train the Department in the use and application of the software. It was agreed that a comprehensive user requirements assessment exercise should be undertaken as a priority activity. Mr Crag Jones estimated that installation, customisation, training in the use of the software, and the reconciliation of all historic data would require approximately 12 man-months.

The possibility of a 'distributed' system to allow data entry from Providenciales, South Caicos and Grand Turk, either via disk mailings or Internet, was discussed. The appropriateness of the FIMS as a regional database to replace the existing OECS/CARICOM system was also discussed.

8.3.3 One-Day FIMS Software Demonstration

It was demonstrated how effort, catch, CPUE costs and earnings results could be grouped by fisherman, boat, fishing method, location, depth, processing plant, island, calendar or season years, months and days as required. The ability of the FIMS to deal with the example 'unanticipated' attributes of Island and Season was demonstrated by placing these in the extra strata fields. The systems ability to deal with data aggregated to varying degrees was successfully demonstrated with historical data provided by the DECR.

The unique method of representing restrictions and licencing to operate within these restrictions was explained showing how all fishing data entered was screened against these criteria. An alternative example was given as to whether the system would be able to reveal any persistent contravention as an aid to assessing the gravity of such problems.

8.3.4 Interim System Training

The prototype version of the FIMS was installed in the DECR to provide an interim system to replace the DataEase system until a fully developed version of FIMS is installed at the Department. An algorithm was included to flexibly define any 'split-year' season and the system was loaded with as much as possible of the Department's historic data. Training was given in data entry and basic reporting. Analyses of catch, effort ,earnings and diversity were demonstrated for various combinations of year, month, day, species, processing plant and

fisherman. It was shown how detailed analyses could be successively grouped up across broader and broader categories. The utility of the generic routines for plotting these results were demonstrated as were the transfer of such plots into reports.

A detailed user manual was provided to support the hands-on training. This manual contained detailed instructions on how to set up and run the system on other machines, as well as details of the errors found in the historical data.

Discussions were held with DECR staff on both the scope of the FIMS system and the constraints imposed by the historic data. It was apparent that the staff had a clear understanding of the data problems highlighted and they were able to propose ways of preventing this in future and suggest methods of resolving queries regarding the historic data. DECR Staff were enthusiastic over the proposed FIMS and expressed clear ideas on how it could broaden the use of their data to answer specific questions they had.

In preparation for the anticipated design and installation of the final version of the FIMS software, potential users were encouraged to 'map' and explain their activities. This will help further refine the 'functional decomposition' of activities within DECR and their external interfaces with other government departments, fishermen, the commercial sector, research and management projects and other agencies.

8.4 Distribution of Final Technical Reports and FIMS Software

In addition to those required to satisfy DFID's contractual reporting requirements, it is intended, at least in the first instance, to send copies of the project's Final Technical Report and FIMS software and User Manual to the following:

Bangladesh
DFID, Bangladesh
DoF, Bangladesh
CARE, Bangladesh
CNRS, Bangladesh
ICLARM, Bangladesh
MACH Project, USAID
Fourth Fisheries Project
EGIS Project
SUFER Project, DFID

Turks and Caicos Islands
DECR
School for Field Studies (SFS)

Africa
Lake Uganda Project, DFID
SADC

9. Summary and Conclusions

9.1 *Purpose and Other Expected Outcomes*

The purpose of this project was to examine the feasibility of developing a generic (generally applicable) Fisheries Information Management System (FIMS) or database to support the co-management and development of a diverse range of artisanal fisheries. In addition to the generic database, other planned project outputs included:

- Guidelines and statistical procedures for a generic data collection system to support the FIMS software.
- An evaluation of the cost of implementing the FIMS (both unit costs and national costs at case study sites).
- Training workshops in the use of the generic FIMS and data collection strategy with supporting material/documents.
- A description of the wider utility and applicability of the generic FIMS.

9.2 *Activities and Outputs - Planned and Actual*

These outputs were sought through a number of planned activities (Figure 29). It was intended to identify generic information outputs from the FIMS on the basis of a synthesis of government and community management objectives identified from the literature, company experience and from case studies of two diametrical artisanal fisheries.

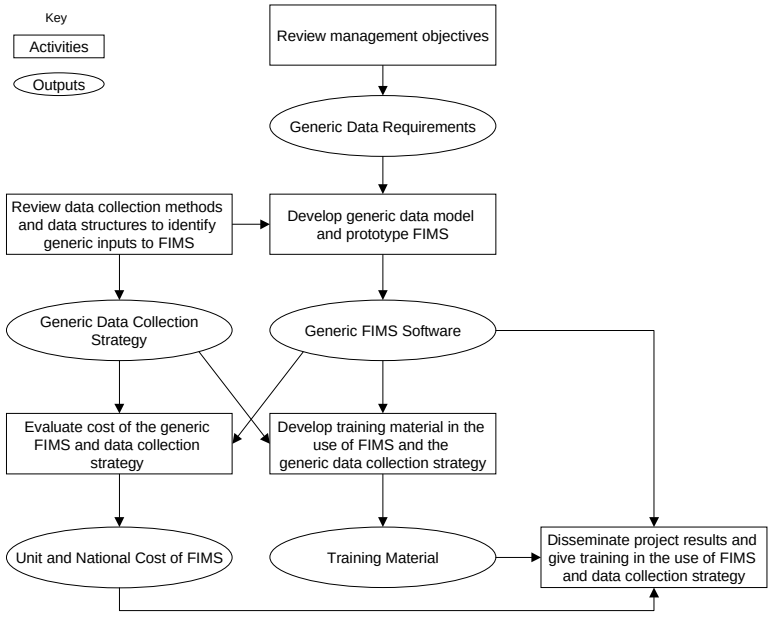

Figure 29 Planned Project Activities and Outputs

The raw data or *inputs* for storing and processing by the database to provide these outputs would be identified from a review of correspondingly appropriate data collection methodologies combined with a review of 'data structures'. This review of data collection methodologies was also intended to provide the basis for developing guidelines and statistical procedures for a

generic data collection system to support the database component of the project. The computing hardware requirements for the FIMS software combined with and necessary resources and manpower to support the generic data collection system would then provide the necessary information to evaluate unit costs of the system, as well as the national costs of implementing the FIMS at the case study locations (Figure 29).

Shortly after the project began, it became evident that information requirements (outputs from the FIMS) to support co-management will be governed by more than just management objectives of governments and local fishing communities (Chapter 3). Instead, the information required from a co-management FIMS will be influenced by (i) the nature of the co-management arrangement which will determine which stakeholders are involved in the management decision-making process; (ii) the objectives of these stakeholders; (iii) the basis with which these stakeholders make decisions (eg custom/tradition, empirical or theoretical models, adaptive approaches...etc); (iv) their institutional capacity which will influence the types of decision-making methods and data collection approaches they can employ; (v) the type of management control measures they choose to employ regulate resource exploitation, and of course: (vi) their preferences and local conditions under which they operate (Chapter 3).

The continuous spectrum and evolutionary potential of co-management arrangements coupled with the inter-dependence among several of the factors listed above, presented a dynamic and multi-dimensional problem to identifying management information requirements and therefore designing a general database to support co-management (Chapter 3).

As a means of addressing the problem, idealised co-management arrangements based upon the work of Sen & Nielsen (1996) and Hoggarth *et al* (1999) were identified for the three main environmental regimes in which artisanal fisheries commonly operate. These arrangements effectively matches the main stakeholders with the necessary motivation and institutional capacity to the main management roles that are heavily reliant upon data and information. This is achieved by sharing management responsibilities for *management units* both spatially and hierarchically (Chapter 3). However, whilst these arrangements provide a useful entry point to examine potential information outputs from a FIMS, it should not be seen as a panacea for co-management. Many other arrangements exist along the co-management spectrum which are equally valid or potentially appropriate depending upon the local context (Chapter 3).

It was also necessary to make explicit which of the main stakeholder groups should be the target of the FIMS. It was concluded that government fisheries departments should be the primary targets because they will usually have overall administrative responsibility for the (co-) management of national fisheries resources. They are also the most likely stakeholder group to possess the necessary institutional capacity and resources to formally monitor management performance and therefore require such a system. Designing a system that could also support the needs of intermediaries (eg donor-funded projects, NGO's etc) was rejected. It would be impossible to anticipate their diverse range of remits and interests and potentially esoteric monitoring programmes commonly designed to satisfy donor-specified project impact indicators (Chapter 4). In spite of this, several NGO delegates at the projects' dissemination workshop in Bangladesh believed the FIMS software could effectively be used in support of many of their community project monitoring and evaluation programmes (see later and Chapter 9). It was also concluded that whilst they are the ultimate target beneficiaries of the project, and may in contribute to the data and information contained within it, it would be unrealistic to expect local fishing communities to have any interest, motivation or the necessary institutional capacity to use such a system. Monitoring and evaluation at this level will typically be informal and often based on perception or common knowledge derived from the co-use of the resource under conditions where mutual observations are possible (See Chapter 4 and Project Memorandum Section 15d).

The system was therefore principally designed to support the following heavily-dependent co-management roles of fishery departments at each of the three nested spatial management levels:

- Formulation of management plans.
- National monitoring and evaluation, and control and surveillance for management plans for migratory[1] and state-owned sedentary resources[2].
- National policy and development planning including the coordination of sectoral activities.
- National and international management and reporting responsibilities.
- Coordination of community management plans to ensure complementarity.
- Evaluation of community management plan performance and feedback of lessons of success and experiences to communities.

It was decided that the FIMS must have realistic limits. The system was not, therefore, designed to provide a means to store, collate and process data and information collected from the infinite range of possible special studies designed to address specific questions such as the migratory behavior of key species. This decision was made on the basis that it would simply be impossible to anticipate all the types and formats of data and information that may be collected as part of such studies.

9.2.1 Identification of Generic Information Requirements (Outputs) from the FIMS

Formulation of management plans
Management plans translate and reference how the broad directions and priorities stipulated within fisheries policy are translated into specific fisheries or stocks profiled in the plan. Generic information requirements to formulate management plans were identified from a synthesis of the literature. The main categories of information included the stocks of fishery being considered and area of operation of the fishery; information on environments, habitats or locations critical for the life history of the stocks or species; potential catchment influences on the stock; information relating to the fishery; information relating to the fishers and other important stakeholders; the management objectives; decision-making arrangements including rules and regulations; and any external factors that may affect management (Section 4.2).

National monitoring and evaluation of management plans, and control and surveillance.
Generic information requirements (outputs) from a FIMS to support national monitoring and evaluation activities were identified from a combination of management objectives (and their *status indicators*), technical management models (and their *reference points*) and adaptive management approaches, covering the full range decision-making methods that are employed to evaluate management performance (see above and Chapter 4).

Surprisingly few (16) explicit statements of management objectives for artisanal fisheries were found in the literature despite the screening of more than 2000 published papers, reports and newsletters. Those found all related to broad over-arching national objectives, policies and plans, or the desired course of action for the fisheries sector. No specific management plan objectives were found. This probably reflects the less formal or structured management procedures employed in artisanal fisheries compared to those in the developed world (Section 4.3).

Generic information requirements (outputs) from the FIMS to support biological or resource

[1]Migratory resources cannot be effectively managed on a local scale.

[2]These refer to non-migratory stocks that are not managed on a local scale.

orientated management objectives, decision-aiding models and adaptive management approaches were identified as catches by species and gear type and corresponding fishing effort by gear type during a specified time period (commonly a year). Other requirements were identified as information to describe the population dynamics of the exploited populations (biological data) derived from the (sampled) including: the length or age composition of the catch and their life history characteristics, typically sex, fecundity, and reproductive condition in relation to length, and gonad weight in relation to somatic weight (Section 4.3).

Spatially referencing these data and information significantly augments its' value allowing: (i) the development of spatial management models (Section 4.3.3); (ii) the identification of important areas for conservation and management (eg spawning locations or nursery areas...etc); (iii) the examination of the spatial and technical interactions among fleets or fishers, and stocks; and (iv) more effective management if the population dynamics of the stock varies significantly on a spatial scale.

Information requirements (outputs) from the FIMS to support common socio-economic management objectives and decision-aiding models were identified to include costs and earnings stratified by various criteria, economic rent, export revenue by species or product type, numbers of individuals employed in the fishery stratified by sub-sector, income stratified by FEU type, industry diversification data, indicators of food supply or security, information describing the extent and frequency of conflicts, information to monitor the existence/maintenance of traditional management practices or culture, and catch and effort information (Section 4.3.4).

Environmental information was also identified as being an important output from a FIMS, particularly to support the management of fisheries operating in environments sensitive to environmental stress or perturbation. The major problem with using environmental data to help interpret management performance is deciding what should be recorded. There is also the risk that apparent correlations with fisheries data are often spurious. General variables that should be available from a FIMS were identified in Section 4.3.5.

Information requirements for control and surveillance were found to typically relate to vessel or gear ownership, identity, communications, fishing power and corresponding licence details (Section 4.4).

National policy and development planning
Information requirements from a FIMS to support national policy and development planning decisions, and reporting responsibilities were examined in Section 4.5. Three main categories of information requirements from the FIMS were identified: (i) resource and fishery related; (ii) socio-economic; and (iii) monitoring control and surveillance (Table 6). Sources for this information were identified as management plans, frame surveys, routine monitoring programmes to evaluate management plan performance, special studies, and information available from other government departments and ministries (eg Departments of Trade, Customs, Bureau of Statistics...etc).

National and international management and reporting responsibilities.
Required outputs from a FIMS to comply with international management responsibilities including the FAO Code of Conduct for Responsible Fisheries and UNCLOS III were identified. Outputs required for international reporting responsibilities were also identified for the main commissions and conventions including the FAO Regional Fishery Commission; Convention for the International Trade in Endangered Species (CITES), and the Convention for Biological Diversity. However, it was recognised that membership to other regional bodies, agencies and organisations such as Organisation for Eastern Caribbean States (OECS) or the South African Development Commission (SADC) may carry with it additional obligations to supply specific information not required for the above (Section 4.7).

Coordination and performance evaluation of community management plans
Adaptive management is likely to be employed by local communities to achieve their objectives for their own *management unit*. However, identifying the best combinations of management tools and decision-making arrangements to achieve specific objectives by individual communities may take several years of (informal) monitoring and evaluation by the local managers. It was concluded that fishery departments or higher level managers have the potential to significantly accelerate this adaptive learning process by monitoring and comparing spatially, performance among individual management plans. The results and management recommendations arising from this approach can then be disseminated to local level managers via appropriate media such as regular radio transmissions, meetings, posters, workshops...etc. This spatial monitoring and evaluation approach also provides and effective means with which to spatially coordinate local management activities thereby promoting harmony and complementarity and helping to minimise conflicts.

Requirements from the FIMS to support this role were therefore identified as being all the information that is typically contained within a management plan and any other attributes that are believed to affect management performance or outcomes, as well as of course, indicators of management performance. It was concluded that the performance indicators must be both relevant and palatable to local level managers if effective feedback and adoption of lessons of success are to be achieved. Whilst these indicators should ideally be selected by the local managers themselves, an extensive literature review discovered no documentation describing management performance criteria as selected and applied by the community itself. Nonetheless, it is recommended that these indicators be negotiated in collaboration with the communities themselves. The DFIDs' five main categories of desirable livelihood outcomes were identified as a useful basis with which to negotiate these indicators (Section 4.9).

9.2.2 Identification of Generic Inputs for the FIMS (database fields)

As explained above, it was intended to identify generic raw data or *inputs* for storing and processing by the FIMS database to provide all the generic requirements (outputs) described above by identifying or formulating a generic data collection system. As a means of attempting to develop such a generic data collection system, factors affecting raw data and their collection and processing were examined in detail in Chapter 5. This included a review of potential sources of data for each required category of requirements, and appropriate data collection tools (eg questionnaires, interviews, direct observation...etc), sampling strata, and the appropriateness of sampling and complete enumeration in relation to the variable or data type in question. It was concluded that it was impossible and wholly inappropriate to design a generic data collection strategy. Effective and appropriate data collection strategies and data processing methods must be designed in accordance to the structure, operations and characteristics of the fishery (the local context), and the available institutional capacity, resources and preferences (see Chapter 5 and Figure 9).

Generic inputs for storage and processing by the FIMS to provide the required outputs were instead identified on the basis of corresponding commonly collected categories of data and information or *generic fields* (Chapter 6). Generic field were identified by reviewing the types of raw data (example fields) that are frequently collected using commonly employed data collection tools and data sources to provide the main categories of information required from the FIMS.

This approach effectively aimed to develop a FIMS that could support a variety of common data collection strategies as opposed to designing a system around a single generic data collection strategy. In addition to increasing the complexity of the database design (and therefore the time and resources required for its development), the inability to develop a generic data collection strategy also had the important implications with respect to delivering several of the

expected/planned outputs (see later).

National management plan fields
Raw data to formulate management plans may be assembled and summarised from a an indefinite number of sources using a variety of data collection tools. Furthermore, management plans often contain information that is not efficiently stored in electronic formats such as lengthy text descriptions or figures. Whilst the final FIMS design can provide much of the raw inputs to construct/formulate a management plan (see below), it was concluded that the complete range of generic input requirements could not be identified and therefore supported by the software. However, the FIMS software does allow management plan document identifiers (their more typical format) to be referenced to all the data contained within the database to aid the coordination of management activities both inter- and intra-sectorally (Section 6.1).

Generic fields for monitoring and evaluation of national management plans:

Frame survey Fields
The information recorded during the frame survey helps identify appropriate primary and secondary sampling units and sampling strata, and provides fundamental data for raising sampled catch and effort data to give the total population estimates (see below). They also commonly provide (either by design or otherwise) an important source of information to help formulate management plans and for policy planning and development purposes, and for socio-cultural analyses (see below). However, in common with management plans, frame surveys also typically draw upon data collected and assembled from an indefinite number of sources using an equally diverse range of data collection tools and methodologies. For these reasons, it was only possible to identify, and therefore include in the software generic, data fields that are required to raise sample estimates of catch and effort to give estimated total values, when sampling as opposed to complete enumeration methods are employed (see Sections 6.2.2 and 6.2.3). The frame survey table does however also contain fields to store information describing the attributes of co-management units and to key identifiers to reference other tables containing basic details of FEUs (see later).

Catch and effort fields
Generic fields to support census and sampling approaches to collecting catch and effort data based upon interview techniques, direct observation and log sheet reporting at the harvest and post harvest levels where successfully identified for inclusion in the software. Consequently, the FIMS provides a very general system for supporting catch and effort sampling programmes (see later).

Biological and Environmental Data
Biological and environmental data are most commonly sampled using direct observations at the harvest level. It was therefore relatively straightforward to identify a comprehensive range of generic fields for inclusion in the database (Section 6.2.4).

Control and Surveillance Data Fields
Generic fields for control and surveillance were also readily identified from the literature and case studies (see Section 6.3).

Socio-economic Data Fields:
Cost and Earnings
Generic fields were identified to support cost and earnings surveys directed either at fishing vessels or households (panel surveys). These fields allow cost and earnings data to be sampled alongside catch and effort data (the 'integration principle') so many of the fields identified are common to those required for catch and effort sampling (Section 6.2.6).

Economic Rent
No additional fields to support the estimation of economic rent were identified. Data to estimate economic rent correspond to those fields already identified to support catch and effort, and cost and earnings studies, and control and surveillance data. Data may also be available from *ad hoc* surveys or other government departments which are typically not included in fishery department databases (6.2.6).

Employment
Fields to record the numbers of fishers employed in the catching sector were identified for frame surveys (See Section 6.2.2). Additional fields to record data on employment in the processing sector could be added to a frame survey table if required. Alternatively, employment data may be available from population censuses or *ad hoc* studies that are typically not included in fishery department databases (Section 6.2.6).

Poverty
Information to assess levels of poverty are available from cost and earnings surveys, combined with living cost data which are typically not recorded by fishery departments. Additional fields to support proxy indicators of poverty recorded during frame surveys were also identified. Other proxies for poverty may be available from population census data available from other government departments or ministries (Section 6.2.6).

Industry Diversification
Fields to support the evaluation of the diversity of the fishery were identified for surveys to support catch and effort surveys (species landed), and frame surveys (gear and vessel types). Additional fields to describe the diversity of supporting sectors recorded during frame surveys were also identified (Section 6.2.6).

Food Supply and Security
Fields to support the evaluation of fish supply and trends in average per capita fish consumption correspond to those already identified to support catch and effort surveys. Alternatively, data may be available from other government departments. Additional fields describing fish consumption or food security recorded during frame surveys were also identified. Common fields to support typical household consumption surveys were identified (Section 6.2.6).

Conflicts and Traditional Management
Generic fields to support the evaluation of conflicts and the maintenance of traditional management by means of ad hoc studies were also identified. These can be appropriately modified in accordance with local requirements. Additionally, a frame survey table could also be customised to accommodate similar fields recorded as part of a frame survey (Section 6.2.6).

Generic Fields for Policy and Development Planning
Generic fields to support policy and development planning are restricted to those corresponding to support of the monitoring and evaluation of management plans (see above). However, other sources of data to support this role may be available from frame surveys or other government departments and ministries (Section 6.4).

National and international management and reporting responsibilities.
Generic fields to provide the basic information required for compliance with international management and reporting responsibilities correspond to those already identified to support the monitoring and evaluation of management plans and control and surveillance. Additional information required to support these roles may also be obtained from other government departments and ministries responsible for trade or customs control (Section 6.5)

Fields for coordination and performance evaluation of community management plans
Generic fields to describe the attributes of co-management units and their respective management performance were identified on the basis of the Oakerson Framework (Section 3.1), ICLARM's 'Institutional Analysis Research Framework' developed under their Fisheries Co-Management Research Project, DFID's Sustainable Livelihoods (SL) framework, and from inter-disciplinary comparative studies of African lake and coastal fisheries described by Preikshot *et al*. (1998) and Nielsen *et al*. (1995), respectively. These fields can be easily and objectively scored on a ordinal or presence/absence score, or quantified using interval or ratio scales if available. Basic ranked scores could be replaced later by more precise values (Section 6.6).

The FIMS currently includes only a subset of attribute and performance fields for demonstration purposes. Further fields can be added when a commonly agreed or standard set of attribute and performance indicators/measures have been identified or developed (see below).

A statistical framework for identifying patterns or similarities between combinations of attributes (explanatory variables) and management performance indicators was proposed based upon Multi-dimensional Scaling (MDS). Using this framework, lessons of success, described in terms of combinations of attributes and levels of inputs that appear to give rise to desirable outcomes or objectives, can then be feedback to local level managers via appropriate media to help accelerate their own adaptive management activities (Section 6.6).

A DFID funded project ' Interdisciplinary Multivariate Analsysis for Adaptive Co-Management' (R7834) is currently developing, refining and attempting to validate this approach in collaboration with ICLARM, IFM, Reading University, DFID and independent consultants.

9.2.3 The Generic FIMS Software

Development
The FIMS software entitled 'PISCES - **P**roviding **I**nformation for **S**ocio-Economic **C**atch and **E**ffort Fisheries Surveys was developed using relational data base and systems engineering theory to satisfy the requirements described above (Section 7). The entire principle on which the system is based is that any activity can be described as having taken place under a set of circumstances recorded as fields effectively within a single table. The value for each of these circumstances is recorded for the activity. The set of circumstances or in technical terms the 'attributes' that describe the situation may include the time and place of the activity along with all the other conditions pertaining to it. These 'attributes' (fields) would describe the conditions pertaining in a household or whilst fishing. Such attributes would be both the inputs and outputs in terms of physical data, measures that profile management areas and measure the performance of management areas. A range of performance attributes can be analysed against any of the physical or management attributes or any number of combinations of these according to the user's choices. This allows a choice of analyses from the traditional physical kinds all the way through to a comparison between different co-management arrangements.

The prototype software is designed to run under Microsoft ACCESS97 (Service Release 2b), although it should also be possible to run the system under ACCESS2000 providing the database is only 'opened' and not 'converted'.

Design Features
The entire core of the system is built around a set of relational tables and accompanying SQL based queries. Specific table structures are composed of clearly defined primary and foreign key attributes. Data 'redundancy' has been reduced to a minimum apart from where redundancy has been deliberately employed to aid generification and handling of missing data. Normalisation and decomposition has been rigorously taken into account. Again as explained earlier there are

deliberate compromises where required to satisfy the requirements for the generic aspects of the design and / or coping with potentially missing data.

All data analyses have been based around relational queries wherever possible. These can be implemented in any system that supports the SQL standard for database definition and manipulation. Thus procedural programming has been kept to a minimum since this is language dependent. Where procedural modules have been used the underlying algorithms have been documented in order to ease implementation in any other system. Cosmetic and other productivity features specific to Microsoft Access have been avoided where at all possible. This again aims to reduce the overheads where the system needs to be implemented in another software system.

Basic Structure
The PISCES software comprises a set of linked reference and survey tables, data entry forms, predefined SQL queries, and plotting and export facilities. The main software control panel software provides access to all the data entry and analysis facilities.

Management plans
Text field references to management plan documents are held in the ManagementPlan Table. A management plan key identifier field effectively allows all the data contained with the PISCES software to be linked to the management plan document.

Generic fields for monitoring and evaluation of national management plans:

Frame surveys
Generic frame survey fields to support catch and effort surveys are held in Frame Table. Data belonging to other the major generic fields identified in Section 6.2.2 that are commonly collected with frame surveys can be held in several other tables linked to the Frame Table including: Disposal Sites, PSUTypes, PSUs, Location Types, Locations, FEUs and FEU types, Gears, Household table (see User manual and Chapter 7). Other fields included in the Frame Table allow the entry of a selection of the measures and indicators to describe co-management attributes identified in Section 6.6.

Catch and effort
The system design supports the four common catch and effort sampling strategies identified in Section 6.2.3. The 'FrameSet' feature (see Section 7.2.9) also allows for the numbers of operational FEUs at each PSU to be updated during each sampling period (See Section 6.2.3).

The main tables used for storing and processing these data are the Frame Table and the Fishing Samples, and Catches tables (see User manual and Chapter 7). PISCES can hold and process all of the generic catch and effort data fields of identified in Section 6.2.3. Standard FAO species codes can be selected from the PISCES Species Table.

Biological and Environmental Data
All the generic biological data fields identified in Section 6.2.4 have been included in the AnimalData Table. These can be linked to catch records (and thereby management plans) via the BiolSamp Table allowing sub-sampled data and information to be correctly raised in proportion to the total catch and spatially referenced. Time constraints precluded the inclusion of fields to record environmental data. These would have been included in the Samples Table.

Control and Surveillance
The majority of the data inputs for control and surveillance identified in Section 6.3 have been included in PISCES in the following linked tables: Frame Table, Sample Table, FEU, FEUtype, Gears, Restrictions, and Licences. The system automatically alerts the user of any

contraventions to licensing restrictions imposed on fishing activity in terms of fishing location, time periods, gear types and species landed. Further restrictions may be added if required.

Socio-economic Data:
Cost and Earnings
PISCES employs the integration principle (Section 6.2.6) to store and process costs and earning data for FEUs in relation to fishing activity. Variable costs corresponding to fishing trip are held in the Samples Table, whilst fixed costs are held in the FEU Table. Most categories of fixed and variable cost data identified in Section 6.2.6 can be accommodated. Earnings are calculated from the corresponding catch data and price data by species type. The FEU table is linked to The TripPeople Table which provides fields to store information on crew income or catch share for each FEU. PISCES also contains a Household Table providing common fields for recording socio-economic data collected with *ad hoc* household surveys. Important fields describe: socio-economic group, annual household fish consumption and annual household income.

Economic Rent
As described above data to estimate economic rent are available from fields already included in the database to support catch and effort and cost and earnings surveys, control and surveillance data, as well as data from *ad hoc* surveys or other government departments which are typically not included in fishery department databases.

Employment
Employment data in the catching sector are usually collected as part of a frame survey. Due to time constraints, fields to hold employment information have not been included in either the Frame table or perhaps more appropriately, within the FEU table. Therefore no employment information is currently provided by PISCES at present.

Poverty
PISCES has the capacity to help calculate poverty measures based upon annual household income fields. Gini coefficients describing the distribution of income among different household types can also be calculated.

Industry Diversification
Fields to support the evaluation of the diversity of the fishery are contained within the Sample Table (species landed), and the FEU Table (gear and FEU types). Additional fields to provide information on the diversity of supporting sectors could be included in the Frame Table as part of a customisation process.

Food Supply and Security
PISCES can provide landings data with which to calculate fish supply and trends in average per capita consumption in conjunction with data obtained from other sources relating to imports, exports and an estimate of the total population. Annual household fish consumption estimates sampled *ad hoc* are also be available from the Household Table. Routine monitoring of household fish consumption (see Section 6.2.6) is not currently supported by the PISCES software.

Conflict and Traditional Management
Due to time constraints, fields to support the monitoring and evaluation of conflicts and the maintenance of traditional management practices were not included in the PISCES software.

Generic Fields for Policy and Development Planning
Generic fields included in the PISCES system to support policy and development planning are restricted to those corresponding to the monitoring and evaluation of management plans (see above).

National and international management and reporting responsibilities
Generic fields to provide the basic information required for compliance with international management and reporting responsibilities are already included in the PISCES to support the monitoring and evaluation of management plans and for control and surveillance purposes.

Fields for coordination and performance evaluation of community management plans
Fields for the coordination and evaluation of community management plans are contained with the ManagementPlan Table, the FrameTable and the Samples Table. As described above, only a selection of those attributes (but no related performance measures) identified in Section 6.6 have, so far, been included in the PISCES software. The system allows the management plan performance fields (described above) to be linked to these attributes. A link to the ManagementArea Tables, which contains location fields (Latitude and Longitude) detailing the position of each co-management unit, provides a basis for spatially coordinating (co-) management activities.

Analyses and outputs
Several predefined analyses have been included in the PISCES software. The results of these and other custom queries can be grouped according to 40 fields including management plan, management area, sampling strata, FEU type...etc, and presented in a variety of plots and figures or exported in Excel spreadsheet format (see User Manual and Chapter 7).

9.2.4 User manual
A user manual has been produced to accompany the PISCES software. This contains sections describing installation, Operation, Data Entry and Data Analysis.

9.2.5 Dissemination
The results of the project were disseminated at the two case study locations between 4th and 19th December 2000 using a combination of workshops, presentations and demonstrations of the FIMS software aimed at target beneficiaries, other stakeholders, and the project's collaborators (Chapter 8).

The workshop in Dhaka, Bangladesh was attended by more than 25 participants representing NGOs, the academic community and international donor and development agencies. Overall, the project results were well received by all participants who expressed an opinion. Representatives of the EGIS project, who have forged a strong working relationship with the DoF during the last two years, believed that the FIMS would be a valuable tool for the Department, and that the system's implementation should be encouraged. EGIS expressed an interest to collaborate with MAG. if an implementation project were funded.

Many participants supported the concept of learning lessons about (co-)management on the basis of spatial comparisons of standard, commonly-agreed management performance measures/indicators and those explanatory factors (co-management attributes) that are likely to affect performance. Many participants representing NGOs recognised that whilst the FIMS is primarily aimed at fisheries departments, the system could also be used as a monitoring and evaluation tool to store and process data on local or small scale projects and studies.

Most of the participants present requested to receive copies of the Final Technical Report and FIMS software so that they could explore the utility and applicability of the system for themselves in more detail.

A separate presentation and software demonstration was also given to the DoF at their headquarters. This was also well attended and received with many staff also expressing an

interest to receive copies of the Final Technical Report and FIMS software. The department also expressed interest in being trained in the use of the software, and thought that the "best bits" of the software should be included in the database which is currently being developed by DoF in association with the Fourth Fisheries Project to replace the existing FRSS database.

Dissemination activities in the Turks and Caicos were attended by staff from the DECR and other Government departments. Unfortunately, stakeholders from the School for Field Studies (SFS), the processing industry, the Fisheries Advisory Committee (FAC) were not represented.

The project results and outputs were well received by the participants, particularly those features relating to the automatic system to alert breaches to technical and licensing regulations. The DECR were also impressed by the flexibility of the FIMS with respect to meeting their reporting requirements and provision of data and information for stock assessment purposes. Some participants were sceptical about the appropriateness of co-management in the TCIs because they believe that communities have no interest in conservation and that resource boundary delineation would be problematic. Conditions to support co-management arrangements were believed only to exist in and around Salt Quay, a small, isolated island with few inhabitants and fishers (see Field Study 2 - Turks and Caicos Islands, Volume II). Others, on the other hand, were enthusiastic about the prospects for co-management and felt that the Department should consult the community more with a view to establishing co-management arrangements. Mark Day, Director, DECR expressed considerable interest in installing the FIMS software in the Department to replace the existing, but no longer functioning, DataEase system (see Field Study 2 - Turks and Caicos Islands, Volume II). He intends to seek DFID development funds for a package to install and customise the FIMS, and to institutionally strengthen and train the Department in the use and application of the software.

The prototype version of the FIMS was installed in the DECR to provide an interim system to replace the DataEase system until a fully developed version of FIMS is installed at the Department and appropriate training was given. A detailed user manual was provided to support the hands-on training, containing detailed instructions on how to set up and run the system on other machines, as well as details of the errors found in the historical data.

Copies of this Final Technical Report, FIMS software and User Manual will be sent to more than 10 donor and development agencies, and NGOs.

9.2.6 Other Planned Activities and Outputs

Because no single generic data collection strategy to support the software could be developed (see Chapter 5) the following two other planned outputs (and corresponding activities) were also not achieved: (i) the estimated cost of the generic data collection strategy in terms of both unit costs and national costs for the two case study fisheries and (ii) training material for the generic data collection strategy.

9.2.7 Summary of Actual Activities and Achieved Outputs

The actual activities and resulting outputs achieved are summarised in Figure 30.

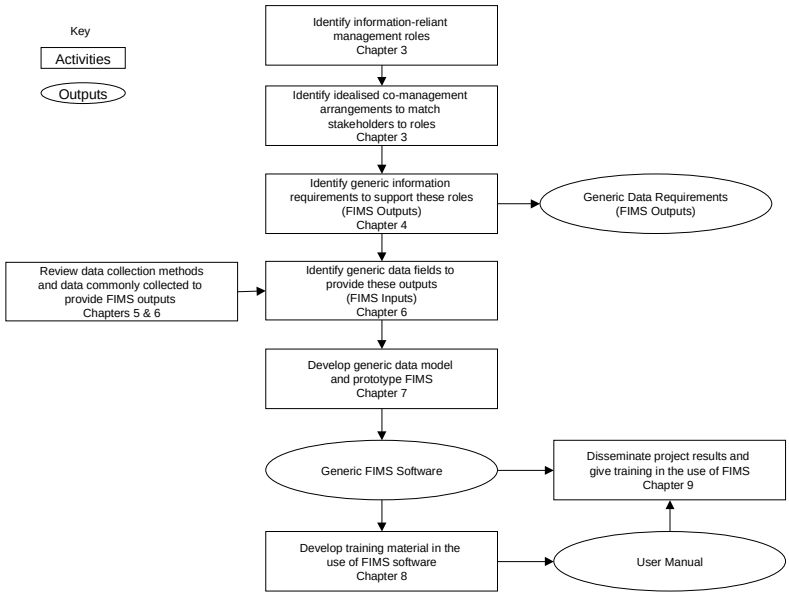

Figure 30 Actual Project Activities and Outputs

9.3 Conclusions

The project has succeeded in fulfilling it's purpose of examining the feasibility of developing a generic database to support the co-management of artisanal fisheries. Prototype software (PISCES) has been developed which can store and process of a wide range of data and information collected using common methodologies to support fundamental co-management roles of fisheries departments. Whilst fisheries departments provide much of the information to support higher level (government) decision-making and policy planning with respect to the fisheries sector, invariably other government departments (eg departments for trade and industry) will be responsible for augmenting these data requirements. The PISCES software is not designed to support these additional requirements. Nonetheless, the PISCES software can:

- Store details of management plan documents with links to key information fields to aid the (spatial) coordination of inter and intra-sectoral management activities;
- Support the monitoring and evaluation of national management plans on the basis of a range of decision-making methods to achieve common management objectives by providing facilities to store and process:
    - Catch and effort data generated by a range of different sampling or enumeration strategies.
    - Biological data sampled by direct observation at the harvest level.
    - Cost and earnings (income) data collected from fishing units (FEUs) or households.
    - Data to help estimate economic rent from the fishery.
    - Sector diversity data (numbers of target species, numbers of different gears and vessel types).
    - Data to help estimate food supply and average per capita fish consumption.

- Support control and surveillance activities by storing information relating to vessel/fisher registration and identification details and licence/quota information. The system also includes facilities to automatically alert breaches to regulations or expired licences.
- Provide information in support of policy and development planning activities.
- Potentially provide all the information required for international management and reporting responsibilities.
- Support the coordination and performance evaluation of community management plans.

All the data and information contained within the database can stratified by more than 5 criteria, spatially referenced, grouped by 40 attributes and either plotted or exported in spreadsheet format.

The key question is how generic or general is the PISCES system? Certain elements of the system will be more generally applicable or generic than others depending upon the specificity of the required outputs and the corresponding range of potential data sources and collection methods.

Outputs that can be explicitly defined including catch and effort, biological, environmental, and control and surveillance data, and information required for international management and reporting responsibilities are all, therefore, likely to be well supported by the software.

Outputs required to support the evaluation of management activities geared towards achieving socio-economic objectives and for policy and development planning purposes are, on the other hand, typically more variable or less explicitly defined reflecting the use of a diverse range of measures, indicators and their proxies, and the wide range of available data collection methodologies and sources. For example, household income and fish consumption data may be monitored either on a routine (monthly) basis by means of a panel survey, or collected during socio-economic baseline/frame surveys. The PISCES software currently does not contain fields or the processing capacity to support the former. Instead fields are provided to record total annual income (from fishing and other activities) and total annual fish consumption generated by annual (ad hoc) surveys.

Fields and data processing facilities provided by the PISCES software for the more explicitly-definable socio-economic data requirements (outputs) such as income (costs and earnings) by FEU type are likely to be more generally applicable.

Data requirements for policy and development planning purposes are often drawn from the results of frame surveys. Frame surveys are also a very general way of collecting data and information about the fishery to help design data collection strategies, formulate management plans, provide baseline socio-economic and employment data, and indicators of poverty, industry diversification, and food security. The types of data and information collected during frame surveys are highly variable. More than 150 example data fields were identified from the literature ranging from answers to specific questions relating to sector support and infrastructure to data on literacy rates of village members (See Section 6.2.2). Whilst many frame survey fields exist in the PISCES software (via linked reference tables with the FrameTable) to record frame survey data, it is likely that significant changes may have to be made to accommodate further fields and to develop appropriate links and processing functions.

Indeed, it is very likely that additional fields may need to be added and existing broad generic fields re-named in several or all of the tables during installation in order to satisfy local requirements and existing data collection systems. In spite of this inevitable customisation, it is estimated that the PISCES software could be installed and working within six weeks

compared to six months to develop a bespoke system. Significant costs savings are therefore anticipated.

Whilst the database has been tested using catch and effort datasets provided by the two case study fishery departments, the extent to which the PISCES system it is generally applicable, particularly with respect to accommodating and processing socio-economic data, can only be assessed after further attempts by fisheries departments to adopt the system.

Other factors may influence adoption or uptake, beyond simply its potential applicability and cost. The system as it stands is very complex and demands a high level of understanding of both data collection systems and relational database theory on the part of users (See Chapter 7 and User Manual). Institutional strengthening and training programmes may well be required for successful adoption and uptake. It's robustness and reliability may also be important, particularly with respect to long term uptake. Further testing of the system and error checking is required. Some participants at the dissemination workshop in Bangladesh believed that potential users may resist uptake because they might perceive an off-the shelf system as less desirable that a bespoke system that has been designed for them according to their own specifications and requirements. Notwithstanding these comments, both fishery departments collaborating on the project, and members of SADC have expressed keen interest in the system (Chapter 8).

9.4 Recommendations for Further Work

Further development of the PISCES software is required to provide the necessary fields and processing capacity to support the monitoring and evaluation of data relating to conflicts, the maintenance of traditional management practices, environmental data and employment in the harvesting (and processing) sectors. Further work is also required to improve the user interface and error checking functions. The system would also benefit from:

(i) some means of simplifying or automating the complex decision-making process surrounding the selection of the appropriate tables in the software for the four main catch and effort data collection scenarios,
(ii) an expanded range of pre-defined queries,
(iii) alternative file export definitions, and
(iv) an expanded range of fields and processing functions for socio-economic data.

The User Manual would also benefit from step-by-step tutorials to guide the user through each database table, feature and function.

It is estimated that this further work would require approximately eight man-months of time to complete. No doubt the further scope for improvements will be identified on the basis of feedback from users.

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Annex 1

Management Control, Enhancement and Rehabilitation Measures
(Management Tools and Operational Rules)

In order to achieve the specific management objectives set out in the operational management plan, various management instruments or *tools* may be used to regulate or control the fishery or resource. These may include regulatory measures or tools applied *directly* to the fishery to limit the amount and type of fishing and who can fish (eg gear restrictions; closed seasons/areas (reserves); licensing; catch quotas; size limits etc), or *indirectly* via fiscal or economic measures (eg fuel subsidies or tax on catch) to either stimulate or check the development of the fishery (Table A1).

Table A1 Common management tools and purposes

Category	Management Tool	Purpose(s)
Effort controls	Reserves	Reduce fishing mortality experienced by stocks.
	Closed seasons	Reduce overall fishing mortality and limit the fishing mortality experienced by small/immature fish to improve yield- or value-per-recruit. and to maintain/increase spawning stock biomass.
	Gear Bans	Reduce overall fishing mortality and limit the fishing mortality experienced by small/immature fish to improve yield- or value-per-recruit and to maintain/increase spawning stock biomass. Reallocate fishery benefits among different fisheries/fishers operating different gear types.
	Gear/ vessel licensing	Limit fishing mortality experienced by stocks. Raise revenue.
Size controls	Minimum mesh sizes	Limit the fishing mortality experienced by small/immature fish to improve yield- or value-per-recruit and to maintain/increase spawning stock biomass.
	Minimum landing sizes	Limit the fishing mortality experienced by small/immature fish to improve yield- or value-per-recruit and to maintain/increase spawning stock biomass.
Catch controls	Total allowable catches / Quotas	Limit fishing mortality experienced by stocks.
Stock Intervention	Species introductions / Stocking	Increase overall productivity/value of fishery. Augment natural recruitment.
Enhancement / Rehabilitation / Habitat protection	Reserves	Protect key habitats for different life history stages of stock.
	Water level manipulation (floodplains / reservoirs etc)	Maintain dry season water levels to maximise survival of spawning stock biomass.
	Sluice gate management (Flood control schemes)	Allow access of fish to impounded areas.
	Environmental protection	Maintain/protect overall integrity and natural productivity of fishery environment.
	Habitat restoration	

Inland fisheries are also increasingly being managed by measures to enhance natural recruitment or the productivity of the fishery, including stocking and fertliziation programmes, culling predator species, the construction of artificial reefs and the rehabilitation of important habitats (Table A1).

The choice of realistic and enforceable management instruments and responsibility for control will largely be dictated by the nature and characteristics of the management unit (local conditions). Contemporary ('top-down') centralised management through regulatory controls may not always be appropriate, particularly for the artisanal sector. For the management instruments to be effective, they must be enforced. Legislative measures may be appropriate for commercial fisheries, but for artisanal fisheries, it is important to reduce the need for conventional surveillance given the limited management resources generally available (Mees, 1998).

Annex 2

Standard Fishing Effort Measures by Gear Categories

Source: FAO (1999b).

Priority Level	Fishing Gear Category	Effort Measure	Definition
First	Surrounding nets (eg purse seiners)	Number of sets	Number of times gear has been set or shot, whether or not a catch was made. This measure is appropriate when school size and packing density is related to stock abundance or sets are made in a random manner.
		Searching Time	This represents time on the grounds less time spent shooting net and retrieving catch as well as tome to hove to. This measure is appropriate when school size and packing density are unrelated to stock abundance and a set is only made when a school has been located.
	Surrounding nets with FAD's eg *Katha*	Number of hours since last fishing this FAD	Time in which FAD is left in water since it was last fished.
	Boat seines	Number of hours fished	Number of hours during which the seine was on the bottom and fishing.
	Beach seines	Number of sets	Number of times the gear has been set or shot, whether or not a catch was made.
	Castnet	Number of casts	Number of times gear has been cast, whether or not a catch was made.
	Trawls	Numbers of hours fished	Number of hours during which the trawl was in the water (midwater or bottom), and fishing.
	Boat dredges	Number of hours fished	Number of hours during which the dredge was on the bottom and fishing.
	Gillnets (set or drift)	Number of effort units	(Length of net expressed in 100m units) x (number of set made)
	Gillnets (fixed)	Number of effort units	(Length of net expressed in 100m units) x (number of times the net was cleared)
	Lift net	Number of effort units	Number of hours during which the net was in the water, whether or not a catch was made.
	Traps	Number of effort units	(Number of days fished) x (number of units hauled)
	Longlines	Number of hooks	Number of hooks fished in a given time period
	Pole and Line	Number of days fished	Number of days on which fishing took place, including days spent searching.
	Rod and Reel	Number of line hours	(Number of hours during which the lines were in the water) x (number of lines used).
	Troll	Number of line days	Total number of line days in a given time period.
	Jigs	Number of line days	Total number of line days in a given time period.

	Other small scale net gears eg push net, scoop net etc	Number of operations	Number of fishing operations whether or not a catch was made.
	Other small scale stationary gears eg bag nets, barrier nets etc	Number of hours fished	Number of hours during which the gears were in the water fishing, whether or not a catch was made.
	Harpoons, spears etc	Number of days fished	The number of days (24hr periods) on which fishing took place, including days spent searching.
Second	Boat seines	Number of sets made	Number of times gear has been set or shot, whether or not a catch was made.
	Trawls	Number of sets made	Number of times gear has been set or shot (either in mid-water or to the bottom), whether or not a catch was made.
	Lift net	Number of hours fished	Number of hours gear has been set or shot, whether or not a catch was made.
	All gears	Number of days fished	The number of days (24 hour period, recorded from midnight to midnight) on which any fishing took place. For those fisheries in which searching is a substantial part of the fishing operation, days in which searching but no fishing took place should be included in 'days fished' data.
Third	All gears	Number of days on ground	The number of days (24 hour period, recorded from midnight to midnight), in which the vessel was on the fishing ground, and includes in addition to the days fishing and searching also all the other days while the vessel was on the ground.
Fourth	All gears	Number of days absent from port	The number of days absent from port on any one trip should include the day the fishing craft sailed bu not the day of landing. Where it is known that fishing took place on each day of the trip, the 'number of days absent from port' should include not only the days of departure, but also the day of arrival back in port. Where on any trip a fishing craft visits more than one fishing area an appropriate fraction of the total number of days absent from port should be allocated to each fishing area in proportion to the number of days spent in each, so that the number of days absent on the trip will be the sum of the number of days allocated to all the different fishing areas visited.
Fifth	All gears	Number of trips made	Any voyage during which fishing took place in only one fishing area is to be counted as one trip. When in a single trip a craft visits more than one fishing area, an appropriate fraction of the trips should be apportioned to each fishing area in proportion to the number of days spent fishing in each so that the total number of trips for the statistical area as a whole will be the same as the sum of the trips to each fishing area.

Annex 3

Data Requirements Specified in the United Nations Fish Stock Agreement

Source: FAO (1999b)

AGREEMENT FOR THE IMPLEMENTATION OF THE PROVISIONS OF THE UNITED NATIONS CONVENTION ON THE LAW OF THE SEA OF 10 DECEMBER 1982 RELATING TO THE CONSERVATION AND MANAGEMENT OF STRADDLING FISH STOCKS AND HIGHLY MIGRATORY FISH STOCKS

ANNEX I
STANDARD REQUIREMENTS FOR THE COLLECTION AND SHARING OF DATA

Article 1

General principles

1. The timely collection, compilation and analysis of data are fundamental to the effective conservation and management of straddling fish stocks and highly migratory fish stocks. To this end, data from fisheries for these
stocks on the high seas and those in areas under national jurisdiction are required and should be collected and compiled in such a way as to enable statistically meaningful analysis for the purposes of fishery resource conservation and management. These data include catch and fishing effort statistics and other fishery-related information, such as vessel-related and other data for standardizing fishing effort. Data collected should also include information on non-target and associated or dependent species. All data should be verified to ensure accuracy. Confidentiality of non-aggregated data shall be maintained. The dissemination of such data shall be subject to the terms on which they have been provided.

2. Assistance, including training as well as financial and technical assistance, shall be provided to developing States in order to build capacity in the field of conservation and management of living marine resources. Assistance should focus on enhancing capacity to implement data collection and verification, observer programmes, data analysis and research projects supporting stock assessments. The fullest possible involvement of developing State scientists and managers in conservation and management of straddling fish stocks and highly migratory fish stocks should be promoted.

Article 2

Principles of data collection, compilation and exchange

The following general principles should be considered in defining the parameters for collection, compilation and exchange of data from fishing operations for straddling fish stocks and highly migratory fish stocks:

(a) States should ensure that data are collected from vessels flying their flag on fishing activities according to the operational characteristics of each fishing method (e.g., each individual tow for trawl, each set for long-line and purse-seine, each school fished for pole-and-line and each day fished for troll) and in sufficient detail to facilitate effective stock assessment;
(b) States should ensure that fishery data are verified through an appropriate system;
(c) States should compile fishery-related and other supporting scientific data and provide them in an agreed format and in a timely manner to the relevant sub-regional or regional fisheries management organization or arrangement where one exists. Otherwise, States should

cooperate to exchange data either directly or through such other cooperative mechanisms as may be agreed among them;
(d) States should agree, within the framework of subregional or regional fisheries management organizations or arrangements, or otherwise, on the specification of data and the format in which they are to be provided, in accordance with this Annex and taking into account the nature of the stocks and the fisheries for those stocks in the region. Such organizations or arrangements should request non-members or non-participants to provide data concerning relevant fishing activities by vessels flying their flag;
(e) such organizations or arrangements shall compile data and make them available in a timely manner and in an agreed format to all interested States under the terms and conditions established by the organization or arrangement; and
(f) scientists of the flag State and from the relevant subregional or regional fisheries management organization or arrangement should analyse the data separately or jointly, as appropriate.

Article 3

Basic fishery data

1. States shall collect and make available to the relevant subregional or regional fisheries management organization or arrangement the following types of data in sufficient detail to facilitate effective stock assessment in accordance with agreed procedures:

(a) time series of catch and effort statistics by fishery and fleet;
(b) total catch in number, nominal weight or both, by species (both target and non-target) as is appropriate to each fishery. [Nominal weight is defined by the Food and Agriculture Organization of the United Nations as the live-weight equivalent of the landings];
(c) discard statistics, including estimates where necessary, reported as number or nominal weight by species, as is appropriate to each fishery;
(d) effort statistics appropriate to each fishing method; and
(e) fishing location, date and time fished and other statistics on fishing operations as appropriate.

2. States shall also collect where appropriate and provide to the relevant subregional or regional fisheries management organization or arrangement information to support stock assessment including:

(a) composition of the catch according to length, weight and sex;
(b) other biological information supporting stock assessments, such as information on age, growth, recruitment, distribution and stock identity; and
(c) other relevant research, including surveys of abundance, biomass surveys, hydro-acoustic surveys, research on environmental factors affecting stock abundance, and oceanographic and ecological studies.

Article 4

Vessel data and information

1 . States should collect the following types of vessel-related data for standardising fleet composition and vessel
fishing power and for converting between different measures of effort in the analysis of catch and effort data:

(a) vessel identification, flag and port of registry;

(b) vessel type;
(c) vessel specifications (e.g., material of construction, date built registered length, gross registered tonnage, power of main engines, hold capacity and catch storage methods); and
(d) fishing gear description (e.g., types, gear specifications and quantify).

2. The flag State will collect the following information:

(a) navigation and position fixing aids;
(b) communication equipment and international radio call sign; and
(c) crew size.

Article 5

Reporting

A State shall ensure that vessels flying its flag send to its national fisheries administration and, where agreed, to the relevant subregional or regional fisheries management organization or arrangement, logbook data on catch and effort, including data on fishing operations on the high seas, at sufficiently frequent intervals to meet national requirements and regional and international obligations. Such data shall be transmitted, where necessary, by radio, telex, facsimile or satellite transmissions or by other means.

Article 6

Data verification

States or, as appropriate, subregional or regional fisheries management organizations or arrangements should establish mechanisms for verifying fishery data, such as:

(a) position verification through vessel monitoring systems;
(b) scientific observer programmes to monitor catch, effort, catch composition (target and non-target) and other details of fishing operations;
(c) vessel trip, landing and transshipment reports; and
(d) port sampling.

Article 7

Data exchange

1. Data collected by flag States must be shared with other flag States and relevant coastal States through appropriate subregional or regional fisheries management organizations or arrangements. Such organizations or arrangements shall compile data and make them available in a timely manner and in an agreed format to all interested States under the terms and conditions established by the organization or arrangement while maintaining confidentiality of non-aggregated data, and should, to the extent feasible, develop database systems which provide
efficient access to data.

2. At the global level, collection and dissemination of data should be effected through the Food and Agriculture Organization of the United Nations. Where a subregional or regional fisheries management organization or arrangement does not exist, that organization may also do the same at the subregional or regional level by arrangement with the States concerned.

Annex 4

Information that should be included in CITES permits and certificates

a) The full name and the logo of the Convention

b) The complete name and address of the Management Authority issuing the permit

c) A control number

d) The complete names and addresses of the exporter and importer

e) The scientific name of the species to which the specimens belong (or the subspecies when it is relevant in order to determine in which appendix the taxon concerned is included)

f) The description of the specimens, in one of the Convention's three working languages, using the nomenclature of specimens distributed by the Secretariat

g) The numbers of the marks appearing on the specimens if they are marked or if a Resolution of the Conference of the Parties prescribes marking (specimens from ranches, subject to quotas approved by the Conference of the Parties, originating from operations which breed animals included in Appendix I in captivity for commercial purposes, etc.)

h) The appendix in which the species or subspecies or population is listed

i) The source of the specimens

j) The quantity of specimens and, if appropriate, the unit of measure used

k) The date of issue and the date of expiry

l) The name of the signatory and his/her handwritten signature

m) The embossed seal or ink stamp of the Management Authority

n) A statement that the permit, if it covers live animals, is only valid if the transport conditions comply with the CITES Guidelines for Transport of Live Animals or, in case of air transport, with the IATA Live Animals Regulations

o) The registration number of the operation, attributed by the Secretariat, when the permit involves specimens of a species included in Appendix I that originate from an operation practicing breeding in captivity or artificial propagation for commercial purposes (Article VII, paragraph 4, of the Convention), and the name of the operation when it is not the exporter

p) The actual quantity of specimens exported, certified by the stamp or seal and signature of the authority that carried out the inspection at the time of the exportation

Annex 5

Documents Reviewed to Identify Generic Data Requirements for the FIMS

Reference	Country	Environmental Regime	Frame Survey	CAS/ Enviro	Biological	Socio-Economic	MCS
(Alamos 1991)	Malawi	Lake		✔			
(Alamos, Seisay et al. 1990)	Malawi	Coastal	✔				
(Alamos and Davies 1991)	BVI	Coastal	✔				
MRAG (1999)	Fiji/Vanuatu	Coastal			✔		
(Barros and Thiam 1998)	Guinea	Coastal	✔				
(Batista, Inhamuns et al. 1998)	Brazil	River	✔				
Bazigos (1983)	General	General	✔				
Brander (1975)	General	General					✔
Caddy & Bazigos (1985)	General	General	✔		✔	✔	✔
(Carrara and Ardill 1989)	Mauritius	Coastal		✔			✔
(Carrara 1987)	Zanzibar	Coastal		✔			
(Carrara 1990)	Mozambique	Coastal	✔				
(Charlier 1995)	Mozambique	Coastal	✔	✔			
(de Graaf and Ofori-Danson 1996)	Ghana	Lake	✔				
(De Graaf 1995)	Lake Volta	Lake		✔	✔		
(Diallo and Diallo 1997)	Guinea	Coastal	✔				
FAO (1996;1997)	General	General					✔
(Anon 1988)	Bahrain	Coastal	✔				
Flewwelliing (1994)	General	General					✔
(Folack and Njifonjou 1995)	Cameroon	Coastal	✔				
(Friedlander and Parrish 1997)	Hawaii	Coastal		✔			
(Hoekstra 1990)	Kenya	Coastal	✔				
(Hoekstra 1992)	Kenya	Lake				✔	
(Horemans, Ajayi et al. 1996)	Gambia	Coastal		✔			
King (1990)	Mauritius	Coastal			✔		
(Langi 1988)	Tonga	Coastal		✔	✔		
(Lartigue and Kingombo 1996)	Angola	Coastal	✔				
(Lartigue and Kigombo 1997)	Angola	Coastal		✔			
(Leendertse and Horemans 1991)	Tanzania	Lake				✔	
(Mandima 1996)	Zimbabwe	Lake		✔			

(Meredith and Malvestuto 1991)	Nigeria	River		✔			
Mees (1998)	Seychelles	Coastal					✔
(Mino-Kahozi, Lubambala et al. 1997)	Zaire	Coastal	✔				
(Moussalli and Bouhlel 1988)	Oman	Coastal		✔			
Field Study 2 (Volume II)	TCI	Coastal		✔			✔
(MRAG 1998)	BIOT	Marine		✔	✔		
Field Study 1 (Volume II)	Bangladesh	Inland		✔			✔
(MRAG 1997b)	Bangladesh	Inland		✔	✔		
Neiland (1997)	Nigeria	Inland		✔		✔	
(Okpanefe, Abiodun et al. 1991)	Nigeria	Coastal	✔				
(Orach-Meza 1991)	General	Lake		✔			
(Paffen, Coennen et al. 1997)	Tanganyika	Lake	✔				
(Rabuor 1991)	Kenya	Lake		✔			
(Rawlinson, Milton et al. 1995)	Fiji	Coastal		✔			
(Razmjoo 1994)	Iran	Coastal		✔			
(SFA 1990)	Seychelles	Coastal		✔			
(Ticheler, Kolding et al. 1998)	Zambia	Inland			✔		
(van Zalinge, Khalilludin et al. 1987) (van Zalinge, Shuaib et al. 1986)	Pakistan	Coastal	✔	✔	✔		
(Wahyudi, Tampubolon et al. 1994)	Indonesia	Marine				✔	
(Westerlund 1994)	Lesotho	Inland				✔	

Annex 6

Sampling Theory

Estimation of population mean and population total using simple random sampling (SRS)
If there are N sampling units in the population, and we measure a desired characteristic y of n randomly sampled units of the population, then

$$\text{Sample mean} \quad \bar{y} = \frac{1}{n} \sum_{1}^{n} y_i$$

The estimate of the population total is given by:

$$\text{Population Total} \quad \hat{Y} = N \bar{y}$$

Sample Size
The required minimum sample size n may be estimated from:

$$n = \frac{s^2}{\delta^2}.(t_{\alpha,v} + t_{\beta(1),v})^2$$

where s^2 is the estimate of the population variance, δ minimum detectable difference between the estimated and actual population mean, α is the probability of committing a Type I error, β is the probability of committing a Type II error, and v is the degrees of freedom (n-1) (See (Zar 1984) for further details). Because v depends upon n, n cannot be calculated directly, but must be by iteration.

Estimation of Proportions
This theory is relevant for biological sub-sampling of catch, for example length frequency sampling. Let there be N units in the population (eg the number of fish of species s, landed at site x, on a particular sampling day), of which N_i belong to i-class (eg size class i), so that the proportion belonging to class i is: $P_i = N_i / N$. We want to estimate N_i and P_i from a simple random sample of n units, in which n_i is in class i so that $p_i = n_i / n$. Then:

$$N_i = N.p_i$$

Stratified Sampling
Suppose there are N sampling units in the population, and these are stratified into k strata with N_i units in the i th stratum. Let a sample of n units be drawn, of which n_i are from the i th strum. Let y_{ij} be the measurement of the j th unit in the i th stratum. Then:

$$\text{Sample mean of the ith stratum} \quad \bar{y}_i = \frac{1}{n_i} \sum_{j}^{n_i} y_{ij}$$

Estimate of the total of the ith stratum $\hat{Y}_i = N_i \bar{y}_i$

Estimate of the population total $\hat{Y}_{st} = \sum_i^k N_i \bar{y}_i$

The allocation of *n* among the different strata can be made either by proportionally or optimally. For proportional allocation, n_i is proportional to N_i. If the within-stratum variances are equal this is the most efficient approach, and used when information on strata variances are not available. When within-stratum variances vary significantly, selecting n_i in proportion to the stratum standard deviation is optimal.

Ratio Estimation

This is a method which uses auxiliary information to increase the precision of estimates. Suppose we have selected at random, *n* units out of *N* units in the population, and for each of these selected units we have measured characteristics, *x* and *y*, where *y* is the survey variate, and *x* is another correlated variate. The population total of the x variate is *known* to be:

$$X = \sum_1^N x_i$$

but *y* may not be known for each unit except for those in the sample. The estimate of the population total *Y* of the survey variate is given by:

$$\hat{Y}_{ratio} = X.\frac{\sum_1^n y_i}{\sum_1^n x_i}$$

Unequal Probability Sampling

Stratification and ratio estimation can increase the precision of the estimate. Another technique for this purpose is the selection of sampling units with probabilities proportional to their sizes (PPS). The technique is commonly used for sampling different size clusters of individual units eg boats, households etc, where all clusters cannot be sampled due to logistical or financial reasons.

Method of estimation

Let there be *N* primary sampling units (eg landings sites) and let x_i be the number of secondary sampling units (eg boats) in the *i*th landing site. If *n* landing sites have been selected with PPS, the probability of selecting the *i*th unit is:

$$p_i = \frac{x_i}{\sum x_i}$$

The estimate of the population total Y is given by:

$$\hat{Y} = \frac{1}{n}\sum_i . \frac{y_i}{p_i}$$

where y_i is the measurement (eg catch) of the i th unit in the sample.

Two-Stage Sampling
In two-stage sampling, a sample of first-stage units (eg landing sites) are chosen first, and in each of the selected first-stage units, a further sample of survey units (eg boats) is chosen. First-stage sampling units may be randomly selected, or selected using PPS.

Two-stage sampling using SRS

Let

N = Number of first-stage units (eg landing sites)
n = Number of first-stage units selected for sampling
Mi = Number of survey units (eg boats) in the ith first-stage unit
mi = Number of survey units selected in the ith first-stage unit.

The estimate of the population total of the survey characteristic y (eg catch) is given by:

$$\hat{Y} = \frac{N}{n}\sum M_i \bar{y}_i$$

where

$$\bar{y}_i = \frac{1}{m_i}.\sum_{j=1}^{m_i} y_{ij}$$

Two-stage sampling using PPS

Where the first-stage sampling units have been selected with PPS, then the estimate of the population total of the survey characteristic y is given by:

$$\hat{Y} = \frac{1}{n}\sum_{i=1}^{n} \frac{\hat{Y}_i}{p_i}$$

where

$$\hat{Y}_i = \frac{M_i}{m_i}\sum_{j}^{m_i} y_{ij}$$

Stratified Two-Stage Sampling
The theory discussed above is applicable when the PSU's are selected from a stratum. To obtain an estimate of the population total (as well as the variance) we simply add the independent estimates obtained within each stratum.